A VIRTUAL DEVICE

Technical field

5   This invention relates to mobile communication systems and
mobile data services in general and in particular a Virtual
Device for use in such systems.

10   ## Technical background

Although mobile and portable devices are getting more and
more advanced and incorporating more functions, it is
foreseen that in the future a user will make use of more
15   and more devices such as mobile phone, PDA (Personal
Digital Assistant), headset, microphone, digital camera,
digital camcorder, etc. The user will have to manage all of
them and it is not always an easy task even for
technicians. It would be nice if the user can consider all
20   the independent devices as one big "Virtual Device" having
multiple input and output units and providing a coherent
and surround interface to the user [1], [2].

Commonly a number of add-on units are available for the
users of mobile devices (cellular telephones and PDAs),
25   like head-sets, web cameras, external keyboards, printers,
etc. These units can be connected to the mobile device
through e.g. a cable, an infrared link or a Bluetooth®
link. However, the mobile device must be designed for
handling these particular external units, and comprise the
30   necessary interfaces and software solutions.

An expansion of this concept is disclosed in Norwegian
patent application no. 1998 5563 to Aktiebolaget LM
Ericsson, now abandoned. This application describes a
component-based terminal, in which the main component (a
35   processing unit for a mobile telephone) is carried by the
user, and in which secondary components; head-sets, display

units, etc., either can be carried on the users body, or be
available in the near environment. Thus, the terminal is
broken up into many separate functional elements. This
means that the resultant terminal can include external
5   facilities like a large stationary display screen, a full
size keyboard or a printer that are available in the room
where the user is situated at the moment (e.g. in his
office); the terminal being configured on-the-fly in order
to add in any components that are available. The
10   configuration is controlled by software agents for each
individual external unit; the agents being contained in the
main component. However, the application does not furnish
any more information on how the components interact or how
the terminal is configured. The setup is locked to the
15   features which are supported by hardware and software in
the main component.

From F. Louagie, L. Muñoz, S. Kyriazakos, "Paving the Way
for the Fourth Generation: A New Family og Wireless
Personal Area Networks", IEEE 56th Vehicular Technology
20   Conference, Vancouver, Canada, September 2002, there is
known a wireless personal network comprising a master unit
controlling a number of primitive add-on units. This is an
elaborate version of the personal network; in principle
known from mobile phones with add-on units like microphones
25   and headphones.

European Patent Application EP 1282282 A2 describes a
personal network in which the JINI service is used to
detect applications installed on the units forming the
network. However, the JINI service cannot discover and add
30   hardware components to a network; it is only able to
recognize applications or services.

Brief summary of the invention

35   It is an object of the present invention to provide a
Virtual Device that combine the abilities and resources of

several independent devices possessed by the user, like
mobile phones, PDAs, etc., by which the user does not have
to purchase the resource twice and hence can save money.

Another object of the invention is to provide a Virtual
5   Device in which the individual devices share resources like
processing power, battery power, memory, data,
applications, network access points and user-interfaces.

Still another object is to provide a Virtual Device in
which the user stores his setup preferences in a user
10 profile avoiding having to enter his preferences in· each
individual device.

The objects above are solved in a Virtual Device according
to the present invention as claimed in the appended patent
claims.

15 In particular, according to a first aspect, the invention
relates to a Virtual Device composed of a multitude of
stationary and/or portable electronic devices, of which at
least one of the devices is a first Open Device with an
available inner structure and a network interface, at least
20 one Primitive Device arranged to communicate with other
Devices and act as a pure slave to said devices,
said Virtual Device further including at least one Closed
Device with a closed inner structure and a network
interface, , said open and closed devices being connected
25 in a Personal Area Network, a Personal Area Network
middleware being installed in said first Open Device, said
first Open Device being arranged to act as a Personal Area
Network controller.

According to a second aspect, the invention relates to a
30 Virtual Device composed of a multitude of stationary and/or
portable electronic devices, including an Open Devices with
an available inner structure and a network interface, at
least one Primitive Device arranged to communicate with
other devices and act as a pure slave to said devices,

which is characterized in at least one additional Open
Device, at least one Closed Device with a closed inner
structure and a network interface, said open and closed
devices being connected in a Personal Area Network, a
5   Personal Area Network middleware being installed on said
Open Devices, said Personal Area Network Middleware being
distributed between said Open Devices, said Open Devices
being arranged to act as a Personal Area Network
controller.

10   According to a third aspect, the invention relates to a
Virtual Device composed of a multitude of portable
electronic devices, including an Open Device with an
available inner structure and a network interface, at least
one Primitive Device arranged to communicate with other
15   devices and act as a pure slave to said devices,
which is characterized in at least one Closed Device with a
closed inner structure and a network interface, said at
least one Closed Device being equipped with a network
interface connected to an external network which includes a
20   Personal Area Network server, a Personal Area Network
middleware being installed on said server, said open and
closed devices and said server forming a Personal Area
Network operated by said Personal Area Network middleware.

According to a fourth aspect, the invention relates to a
25   Virtual Device composed of a multitude of stationary and/or
portable electronic devices, which includes a Closed Device
with a closed inner structure and a network interface
connected to an external network, at least one Primitive
Device arranged to communicate with said Closed Device or
30   devices and act as a pure slave to said device or devices,
a server in said external network on which is installed a
system and network management software, said server being
arranged to communicate with said Closed Device or devices
in order to act as a Personal Area Network controller.

Brief description of the drawings

The invention will now be described in reference to the
5 appended drawings, in which

Figure 1 is an overview showing devices that might be
included in a Virtual Device in a Personal Area Network
according to the present invention,

Figure 2 is a schematic diagram showing the overall
10 architecture of a Personal Area Network,

Figure 3 is a diagram showing a Virtual Device on a PAN
with a unique Open Device,

Figure 4 is a diagram showing a PAN application structure,

Figure 5 is a diagram showing the organization of the
15 Personal Area Network Middleware for a Virtual Device on a
PAN with a unique Open Device,

Figure 6 is showing a Virtual Device on a PAN with multiple
Open Devices,

Figure 7 is showing the Personal Area Network Middleware
20 for a Virtual Device on a PAN with multiple Open Devices,

Figure 8 is showing a networked PAN without any Open
Device,

Figure 9 shows a Virtual Device on a networked PAN with an
Open Device,

25 Figure 10 shows the Personal Area Network Middleware for a
Virtual Device on a networked PAN with an Open Device.

Detailed description of the invention

With the emergence of local short-range communication
30 technologies such as Bluetooth [3], WLAN [4], HiperLAN,

etc. local connectivity between devices is enabled. The
devices belonging to a person will form a private Personal
Area Network (PAN) where devices appear and disappear
dynamically. However, most importantly, connectivity does
5   not necessarily mean communication and many challenging
issues must be resolved before devices can collaborate and
together form a Virtual Device. This invention proposes and
describes a PAN middleware that enables the formation of a
Virtual Device on the PAN and that is capable of handling
10 the dynamical presence of devices and the diversity of
device types.

This invention can be realized in at least four different
embodiments:

1. An architecture and the necessary middleware functions
15   to realize a Virtual Device based on an isolated PAN
        (Personal Area Network) with a unique open device

2. An architecture and the necessary middleware functions
        to realize a Virtual Device based on an isolated PAN
        with multiple open devices.

20 3. An architecture and the necessary middleware functions
        to realize a Virtual Device based on networked without
        open device

4. An architecture and the necessary middleware functions
        to realize a Virtual Device based on networked with
25   open device

In order to realize the Virtual Device, the PAN and his
devices must be hidden to the user and his applications and
this is done by introducing a PAN middleware.

30 As shown in Figure 2 the PAN middleware must be capable of
handling not only the Personal Area Network but also the
heterogeneity and the dynamic of devices. There are
precisely these two characteristics that make the PAN
middleware different from the traditional Distributed

Computing Middleware where the computing nodes are supposed
to be stable and equal or at least having the minimum of
capabilities e.g. processing, storage, communication, etc.

5   Indeed, on the PAN there are a variety of devices such as:
     • Communications devices (fixed, mobile &IP phones)
     • Computing devices (Computer, PC, laptop, PDA, etc.)
     • Peripheral devices (Printer, scanner, digital camera,
       camcorder, etc.)
10   • Electronic devices (TV, stereo equipment,
       loudspeakers, etc.)
     • Electronic appliances (fridge, espresso machine,
       washing machine, etc.)

15   The devices can be:
     • On-body or Off Body
     • Mobile or stationary
     • With or without Network connections
     • With or without local wireless connections
20
     It will be necessary to differentiate the device types as
     follows:
     • *Primitive device:* Simple devices that cannot operate
       alone but are slave to other devices, e.g. earphone,
25   microphone, display, etc.
     • *Open device:* Devices allowing the installation and
       execution of PAN Middleware and other applications,
       e.g. PDA, laptop, workstation, etc.
     • *Closed device:* Devices that can operate stand-alone
30   but are like a black box i.e. its internal structure
       and functions are totally hidden and communicate with
       the environment though only well defined interfaces.
       For instance, a digital camera is advanced device
       having processor, memory, input and output units but
35   does not allow the installation and execution of
       foreign applications. It communicates with the rest of
       the word via interfaces like serial, parallel, USB,
       etc.

Let us now successively consider the following four solutions as follows:

- Virtual Device on isolated PAN with unique Open device
5   - Virtual Device on Isolated PAN with multiple Open devices
   - Virtual Device on Networked PAN without Open device
   - Virtual Device on Networked PAN with Open device

VIRTUAL DEVICE ON ISOLATED PAN WITH UNIQUE OPEN DEVICE

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In this PAN configuration, there is no device having connection with any wired or wireless network. There is only one *Open* device while the rest is either *Primitive* or *Closed*. Figure 3 shows a Virtual Device on a PAN with two
15   primitive devices: microphone and earphone, two *Closed* devices: Mobile phone and Camcorder, and one *Open* device: PDA.

In such a PAN it is desirable to achieve the following:
20   - All the *Open* and *Closed* devices should have the ability to use the Primitive ones i.e. the mobile phone, the camcorder and the PDA should be able to share the microphone and the earphone. It is worth noting that today, such a device sharing is not
25   supported with Bluetooth.
   - The *Open* devices should have the ability to use *Closed* devices. This is possible although very dependent on the interfaces offered by the *Closed* device. For example, the PDA can only communicate with the mobile
30   phone using the AT command [5] to make e.g. a call request.
   - The *Closed* devices can only user other Open or Closed devices if they are programmed for that.

35   A PAN middleware is necessary to achieve the resource sharing as above. In this case the PAN middleware is

located on the PDA since it is the unique device capable of
accommodating the PAN Middleware (PANM).

Let us now define the necessary capabilities and functions
5   for this configuration.

A. Device Profile

The PANM should be able to detect and to recognize what are
10   the devices present in the PAN, what type they are and what
capabilities they have or what service they are offering,
e.g. printing, sound input, text displaying, etc. The PANM
must have the mechanism to handle the device profiles
containing device type and capabilities and to do the
15   comparison with detected devices. The definition of device
types must be logical and unambiguous definition of device
types. It must be logical to address both composite devices
and inherited devices. It must be unambiguous to guarantee
the identification of a device type. Ideally, the
20   definition of device types should be standardized.

B. Resource Discovery and Updating

The Resource Discovery comprises both the Device and
25   Service Discovery. To support the PAN's dynamic where
devices appear and disappear, the PANM should be equipped
with mechanisms for Device Discovery and Updating. One
alternative is to carry out polling periodically. Since
Primitive devices may be tied to their master and not
30   visible to other, the PANM should also ask also Open and
Closed devices for Primitive devices connected to the
device. In a second alternative, the PANM only run the
device discovery once and relies on triggering from the
network layer to update its device set. In a third
35   alternative, the changes are only updated when an attempt
to reach a device upon request from an application fails.

The PANM should also store the present devices. It is hence necessary to have a naming convention, e.g. PDA 1, Mobile 2, etc. The network addresses (IP, Blutetooth, etc.) and protocols for each device must also be saved.

5

C. Device Input and Output redirection

The PANM should be able to redirect an output stream from one device to the input stream of another one. For example
10 the sound output stream from the PDA can be redirected to the earphone and the sound input redirected to the microphone. It must intercept the output stream addressed to a device at an output port, perform the necessary transformation and send it to another device on the PAN. An
15 API (Application Programming Interface) should be defined

D. Application/Service Input and output redirection

The input and output redirection should also be done at the
20 application/service level, i.e. one application can be redirected to one device while a second one to another device. However, this capability is more difficult since it depends on the feature of the operating system and may also require a new application structure as shown in Figure 4.
25 An application consists of three components: Core, Input and Output. The Core component contains the main logic of the application and should remain invariant. The Input and Output Components should be specified according to the services supported such as sound input, text input, graphic
30 display, colour printing, etc. If a device offers a service matching the one required then it can be used for the application.

E. User Profile Management

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The user and owner of the PAN should be reserved the right to define the following:

- What devices are allowed to participate to his PAN when present within the PAN's coverage.
- How the devices should be used at a particular location or at a particular time or according to a certain timetable. How should the redirection between devices be
- Which device should be internal and which one should be global and visible to the outside world.
- Which applications and their settings
- How should the applications should be distributed among the devices, i.e. how the three components should distributed among devices according to criteria as quality, price, battery level, etc.

In addition, the user must have the ability to alter, remove, and add device and applications at any time and anywhere. These hard requirements put quite a lot of challenge on the design of the User Profile structure and the architecture of the system around it.

F. Interface to the user

Since the user, as owner of the PAN, should be the one having the right to decide everything, there is a need for an application called PAN Control that offers interfaces allowing him/her to communicate and control the PAN Middleware. As other applications, the PAN Control should be also structured as Core, Input and Output and should support a variety of input and output services.

G. Interface to applications and services

With the apparition of the PAN, a brand new type of applications called PAN-based applications is born. This new type of applications will actively take advantage of the unique properties of the PAN: device dynamic and resource sharing. A typical example of PAN-based applications is an application, which focuses on the

control of existing applications, their parallel execution, their flexible and dynamic composition, the distribution of their input and output. The PANM should provide an Application Programming Interface (API) allowing the
5   application access to the PAN capabilities and functions. Such an API can be implemented in different technologies, e.g. Java, CORBA, XML Web service, etc.

H. Summary
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Generally, to realize a Virtual Device on an isolated PAN with a unique Open device the PAN middleware must be installed and executed on this unique Open device.

15 As shown in Figure 5 the necessary capabilities and functions in the PAN Middleware (PANM) in the case of an isolated PAN with unique Open Device are:
   * Device Profile
   * Resource Discovery
20 * Device Redirection
   * Application Redirection
   * User Profile Management
   * PAN Control
   * PAN API
25

This PAN configuration depends totally on the central device, the open device and will collapse when the open device disappears, is switched off or runs out of battery. Another disadvantage is the limitation of the resource
30 sharing since most of devices are *Closed* and *Primitive* and hence impenetrable.

VIRTUAL DEVICE ON ISOLATED PAN WITH MULTIPLE OPEN DEVICES

In this PAN configuration, there are now multiple *Open*
35 devices, multiple *Closed* devices and multiple *Primitive* devices. Figure 6 shows a Virtual Device on a PAN with two *Primitive* devices: microphone and earphone, two *Closed*

devices: Mobile phone and Camcorder, and three *Open* devices: PDA, Laptop and PC.

5 In such a PAN, in addition to the features identified for the previous case it is desirable to achieve better collaboration and more optimal resource sharing between the *Open* devices. The PANM as defined in the previous case can now be distributed among the *Open* devices.

10 We present now successively all the possible alternatives for the distribution of the PANM (PAN Middleware) and resource sharing on the *Open* devices.

A. Distributed Operating System

15

In this alternative, the PAN Middleware is a Distributed Operating System deployed on all the Open devices and coupling them tightly as one. Such an alternative demands the implementation of the Distributed OS on all the Open
20 device types and with the rapid growth in type of mobile devices this could be difficult. Another disadvantage is that the device dynamic can create serious problem for the Distributed OS that requires much stability.

25 ## B. Distributed Computing

In this alternative, the PAN Middleware is a Distributed Computing Middleware, which hides the distribution and communications from the applications and application
30 developers. In order to be able to support PAN, the traditional Distributed Computing Middleware must be extended with functionality to cope with the dynamic of devices. This alternative has an advantage compared to the previous in the sense that there are fewer operating
35 systems and the number of Middleware implementations is lower. On the other, it is important to quantify the overhead introduced and to investigate whether it is

acceptable for mobile devices with limited processing and
storage capabilities and battery life.

C. XML Web Services

5

In this alternative, the PAN Middleware consists of the
logic necessary to expose the capabilities and functions of
each Open device as an XML (eXtensible Markup Language) Web
services [6]. The other Open devices can hence invoke these
10 Web services by using SOAP (Simple Object Access Protocol)
[7]. With the Web service concept unlike the Distributed
Computing the distribution is not hidden. Entities know
that communicate with remote entities but communication is
made simpler by the automatic generation of SOAP message.
15 This alternative requires that a Web service platform is
installed on each Open device offering Web service and this
could create an overhead to the PAN. However, the devices
are more loosely coupled in this alternative and it can
cope better with device dynamic.

20

D. Application distribution, coordination and control

In this alternative the PAN Middleware performs the
distribution, coordination and control of applications
25 based on the application structure: Core, Input and Output.
The distribution of the input and output components is
already taken care by the Application Redirection Function
mentioned earlier. Concerning the Core, it could only be
moved and resumed on compatible Open device, i.e. devices
30 capable of supporting it. For example, an application Core
written in Java can only be moved to a device having a Java
Virtual Machine and not to a MS Windows device. To achieve
the application migration, the mobile agent concept can be
appropriate since an agent can stop the execution of an
35 application, serialize it, transport it to another device,
de-serialize and resume the execution.

E. SUMMARY

Generally, to realize a Virtual Device on an isolated PAN with a multiple Open devices the PAN middleware should be
5 *distributed among the Open devices. To achieve the distribution of the PANM and resource sharing between Open devices a new function is introduced in the PANM called Resource Sharing. The Resource Sharing can be realized by one or combination of the approaches: Distributed Operating*
10 *System, Distributed Computing, XML Web Services or Application distribution, coordination and control.*
To achieve optimal resource usage a Resource Sharing function is required in the PANM as shown in Figure 7. The necessary capabilities and functions in the PAN Middleware
15 (PANM) in the case of an isolated PAN with multiple Open Devices are:

- Device Profile
- Resource Discovery
- Device Redirection
20 - Application Redirection
- User Profile Management
- Resource Sharing
- PAN Control
- PAN API

25 **VIRTUAL DEVICE ON NETWORKED PAN WITHOUT OPEN DEVICE**

In this configuration the Virtual Device does not have any *Open* device but only either *Primitive* or *Closed* device. Usually as mentioned earlier, without an *Open* device, the
30 Virtual Device will collapse but fortunately there is a way to remedy the situation if there is one device with network connection.

As shown in Figure 8, the mobile phone allows communication
35 with a Computer running PAN Middleware. In this case the PAN can function very well because it is logically equivalent to the configuration *Isolated* PAN with unique

Open device if the Computer on the network is considered as
a PAN device. This configuration is, however, very
interesting since it opens for several relevant usage.
Indeed, the network computer can be Home PC or the office
5   workstation that the user always leave behind when
traveling but it can still participate and give support to
his PAN. This network computer can also be provisioned and
managed by a Service Provider that offers PAN service to
the users.
10

SUMMARY

Generally, it is possible to realize a Virtual Device on a
networked PAN without any Open Device if the user has an
15 *Open device on the network (Internet) running the PANM.*

1.1.1.   VIRTUAL DEVICE ON NETWORK PAN WITH OPEN DEVICE
In this configuration, the PAN has all the device types:
Open, Closed and *Primitive* but also those having network
connection. This configuration is logically equivalent with
20 the Isolated PAN with multiple Open devices. However, as
shown in Figure 9 in order to reduce the usage of the
network connection, it is perhaps desirable not to have
tight coupling between the PDA on the PAN and the network
computer. The network computer in this case acts as a safe
25 storage and a *Synchronization function* should be added in
the PANM (PAN Middleware) as shown in figure 10. The
synchronization function ensures the consistency of the
Virtual Device data, settings and profiles.

30 It is also quite useful to include a *Device Software*
Installation and Updating function that offer the
possibility to search, select, download and install the
appropriate software version for a device on the PAN. When
the user wants to add a new device in his Virtual Device
35 specific software, e.g. drivers, plug-ins, etc. may be
required. The Device Software Installation and Updating

function may carry out the necessary operation and allow seamless introduction of new devices to the Virtual Device.

SUMMARY

5 *In a Virtual Device on a networked PAN with Open Device,
the Open Devices both on the PAN and on the network
(Internet) should run the PANM.*

The necessary capabilities and functions in the PAN
10 Middleware (PANM) in the case of a networked PAN with Open
Device are:
- Device Profile
- Resource Discovery
- Device Redirection
15 - Application Redirection
- User Profile Management
- Resource Sharing
- Synchronization
- Device Software Installation
20 - PAN Control
- PAN API

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